The Integrator

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# A Message from the Associate Director of Flight Projects for the Mission Services Program

I would like to take this opportunity to welcome everyone into the new millennium. I want to thank each and every person who worked hard to ensure our systems were Y2K compliant. Many of you spent the majority of 1998 and 1999 testing, updating, and validating 30 percent of NASA's Mission Critical Systems to prepare for the transition. As the New Year rolled in, all of our systems transitioned over successfully, starting with the elements at the South Pole. This endeavor exemplifies our continuing effort to promote the health and safety of all of NASA's spacecraft and mission support systems.

We exited the 20th century with a bang. In 1999 alone we supported approximately 50 on-orbit NASA missions, the launches of 25 Expendable Launch Vehicles, three Shuttle missions and several Long Duration Balloon Program missions. We ended the century with two major successful undertakings—the launch of the Terra satellite and the Hubble Space Telescope Servicing mission—while simultaneously supporting the KOMPSAT and ACRIMSAT launches.

As we embark on the 21st century, there are many new and exciting projects on the horizon. We are preparing to support the launches of the Geostationary Operational Enviromental Satellite (GOES), the Earth Observing (EO-1) satellite, and TDRS H. Speaking of TDRS H, work is being completed that will enable its placement in storage and shipment to the Cape for launch in June 2000. Congratulations to the TDRS team members; to prepare the spacecraft for launch, they have overcome many challenging technical and contractural issues within the new (for GSFC) "fixed price" contract vehicle. With the launch of TDRS H, the Space Network will be able to continue its heritage of reliable services and provide new capabilities to our customers. In addition, six months of GSFC participation in the Mars Network effort has paid off. A MARSAT study is expected to begin in March, and project development is anticipated in less than one year.

To add to the excitement of the new millennium, RSDO released the Rapid II Spacecraft Procurement offering in January. This new offering will allow customers to procure spacecraft services quickly and easily, while lowering overall mission costs.

As we move forward into the 21st century, I am confident that the MSP organization will remain a vital component of our Enterprise customers' missions. We continue to promote technologies and capabilities that meet the needs of missions of today and tomorrow. I look forward to the new century and the opportunities we have to provide valuable, mission-enabling services.

*Phil Liebrecht*

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**Highlights in This Issue...**

# *In This Issue ...*

# Mission Services Program Elements

## Network Control Center News

The Network Control Center (NCC) has several ongoing activities and significant accomplishments to report in this issue of *The Integrator.* Currently, operations personnel are participating in meetings to plan for the Data Services Management Center (DSMC). The DSMC is a Consolidated Space Operations Contract (CSOC) initiative that includes plans to move all NCC functions to the White Sands Complex (WSC) by spring of 2002.

In addition, the NCC provided excellent scheduling and operational support in mid-December to support the ATLAS/ Terra launch and the STS-103 Shuttle mission. The Terra launch occurred on December 18, 1999 (see page 11) and the STS-103 launch occurred on December 20, 1999 (see article page 10). Due to the close schedules of the two missions and subsequent launch slips, NCC personnel were required to perform extensive scheduling/conflict resolution to support these events.

NCC scheduling personnel received a message of thanks from NASA for assisting with scheduling extended TDRSS events for McMurdo TDRS Relay System (MTRS) engineering work. During this engineering effort a significant amount of TDRS time was requested and provided. Most of this time was requested in near real-time, often requiring additional support from the WSC and/or NCC/Network Integration and Analysis teams.

NCC preparations for the Year 2000 (Y2K) were successful, and no significant problems were encountered during the roll over. The NCC participated in several drills and prepared notebooks containing all necessary information for the Technical Manager (TM), which included the Business Continuity and Contingency Plans (BCCP), reporting forms, contact numbers and instructions. The NCC TM served as the Space Network Y2K Element Manager, as well as the Building 13 Complex Manager. Additionally, the NCC hosted the NASA Code 450 Y2K Managers during the zero-day activities. Operations personnel also developed and issued a Special Event Instruction (SEI) for the Operations team to follow, with a timeline of activities, including schedule and vector transmissions to prepare for the rollover. AMDSX (Administrative Message Distribution System X-Windows) is currently in final testing. Once testing and transition are complete, the AMS (Administrative Message System) will be turned down.

The Ground Network Scheduling System Replacement (GNSSR) is now fully operational. This system was developed for Y2K compliance, and automates report generation. In addition, the first NCC Software Maintenance Release will be delivered at the end of February, after the STS-99 mission (for more information, see article below). The Operational Readiness Review (ORR) was conducted Thursday, February 10. Minor issues are being worked and the delivery is expected to be on schedule.

The NCC was prepared to handle any contingencies arising from the November Leonid meteor storm, and imposed a 24-hour hardware/software freeze on the Network. Fortunately, no customer or network problems related to the storm were reported.

In addition to the activities described above, the NCC has supported nine Expendable Launch Vehicle (ELV) launches and two Space Shuttle missions since October 1, 1999.

A full Auxiliary Network Control Center (ANCC) operational fail-over is being planned. Hardware/Software issues are still being worked to allow this fail-over in the near future. NCC personnel are also working to implement a new improved STDN Daily Report format. The new format will consist of an MS Word document with tables.

*By Joe Snyder/ATSC*

*For further information, please contact Bill Webb/GSFC Code 451 at (301) 286-3264 or visit http://ncc.gsfc.nasa.gov on the World Wide Web.*

## NCCDS Maintenance Status and Future Plans

The Year 2000 (Y2K) came and went quietly for the Network Control Center Data System (NCCDS). Actually, it came and went twice, as the NCCDS had to brace itself for GMT rollover, and for midnight, Eastern Standard Time. The non-occurrence of Y2K problems left many support personnel all dressed up with nowhere to go—and very relieved (and with plenty of bottled water leftover!).

The first Maintenance Release of NCCDS 98, dubbed Release M00.1, has successfully completed testing and is awaiting transition into operations. This transition is expected to take place immediately following the completion of STS-99. (We anticipate that this transition will already be accomplished by the time you read this article.) M00.1 resolves some 107 problem reports and an NCC Change Request. With these changes, the NCCDS will become more stable, reducing the number of workarounds and the amount of human intervention by the sustaining engineering team.

The second Maintenance Release, M00.2, is to begin system testing at the end of February. This release is the major component of the maintenance effort. The contents of this release, which can be reviewed at *http://ncc98.gsfc.nasa.gov/bld-cont/m002.stm*, include solutions to over 70 problem reports and 22 NCC Change Requests. Release M00.2 includes major redesigns of Wait List Processing, TDRS Mapping changes, and processing of requests from the autoqueue. This release also includes performance improvements for many of the operator windows, allowing the operators to do their jobs more efficiently. M00.2 also contains the NCCDS changes for the final phase of the Space Network Interoperable PN Code Libraries. This release is targeted for transition into operations sometime in June 2000.

Planning for the third Maintenance Release is just beginning. This release is envisioned to be a clean-up release for problems introduced in M00.2, along with any additional requests from operations. Defining the contents for M00.3 will probably be more iterative than for the two previous releases, because Release M00.3 must be planned around other NCC activities.

Specifically, the NCCDS will now begin preparation for its move to the White Sands Complex (WSC) in New Mexico, to become a major component of the Consolidated Space Operations Contract's (CSOC's) Data Services Management Center (DSMC). As part of this preparation, the Communications and Control Segment (CCS) and the NCC Test System (NTS) are being rehosted on more compatible hardware. This preparation will include an architecture and design freeze for the NCCDS beginning around January 2001.

*By JR Russell/CSC*

*For more information about the NCC completion and/or maintenance releases, please contact Roger Clason at (301) 286-7431.*

## EBNet Supports Terra Launch

Terra successfully launched from Vandenberg Air Force Base (VAFB) on Saturday, December 18, 1999. Terra, previously called AM-1, carries a payload of five sensors that will study the interactions among the Earth's atmosphere, lands, oceans, life, and radiant energy. The payload consists of the Advanced Spaceborne Thermal Emission and Reflector Radiometer (ASTER), Clouds and Earth's Radiant Energy System (CERES), Multi-angle Imaging SpectroRadiometer (MISR), Moderate-Resolution Imaging Spectroradiometer (MODIS), and Measurements of Pollution in the Troposphere (MOPITT) instruments. This instrument complement was selected to obtain information about the physical and radiative properties of clouds; air-land and air-sea exchanges of energy, carbon, and water; vertical profiles of gases; and volcanology. CERES, MISR, and MODIS are provided by the United States. MOPPIT is furnished by Canada, and ASTER is being provided by Japan. Data will be collected 24 hours a day and recorded onboard.

Code 290 (with associated support contractors, including Lockheed, EER, GTE, and Raytheon) provided support for the Terra launch at VAFB, Goddard Space Flight Center (GSFC), and the White Sands Complex (WSC). They continue to supply network support for the mission over the Earth Observing System Data and Information System (EOSDIS) Backbone Network (EBNet). EBNet is providing ground station network support for Terra using Timeplex multiplexers at GSFC, the WSC, the Svalbard Ground Station (SGS) at Longyearbyen in Norway, the Wallops Ground Station (WGS), and the Alaska Ground Station (AGS) at Poker Flat, Alaska. For this mission, clock and data communications support is being provided between the ground stations and the EOS Data and Operations System (EDOS) at GSFC. Science data will be processed to Level 0 and distributed to the EOS Distributed Active Archive Centers (DAACs) for science community retrieval over the EBNet using Internet Protocol (IP). In the near future, the clock and data interfaces from GSFC to the ground stations will be converted to IP.

Currently there is a T1 circuit (1.544 Mbs) from GSFC to the ground station in Norway. An additional circuit, an E1 (2.048 Mbs), is scheduled to be in place by the beginning of March 2000 to increase the bandwidth available to the SGS.

*By James M. Cameron/GSFC Code 291*

*For additional information, please contact the author at (301) 286-6287 or via email at james.m.cameron.1@gsfc.nasa.gov.*

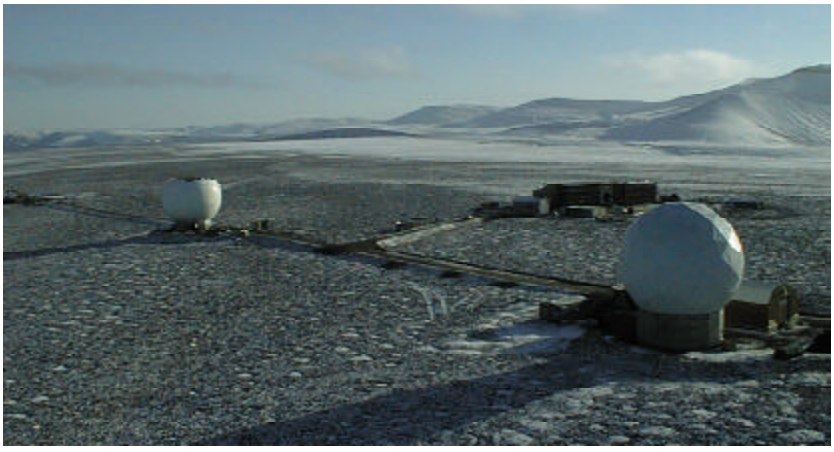
## EOS Polar Ground Stations Operational

With the successful support of several new missions in 1999, the EOS Polar Ground Stations (EPGS), an element of the Mission Services Program Office's Ground Network (GN) Project, have consistently met or exceeded the requirements of flight project customers. EPGS support for the launches and subsequent orbital passes of Landsat-7 (April 15, 1999), QuikSCAT (June 19, 1999), Terra (December 17, 1999), and Acrimsat/Kompsat (December 21, 1999) were a true test of the new GN capabilities. Although EPGS staff had to deal with issues such as very sensitive recording devices, the introduction of new systems and operators, and scheduling conflicts during overlapping launch activities, EPGS's overall performance was in the 98% plus range. Its level of performance continues to improve, with consistent daily performance levels of 100%.

*By Bob Stelmaszek/ITT*

*For further information, please contact Steve Kremer/WFF Code 452 via email at steven.e.kremer.1@gsfc.nasa.gov.*

AGS Facility with 11 Meter Antenna (Left Rear)



SGS 11 Meter Antenna (right radome) and Building in Background

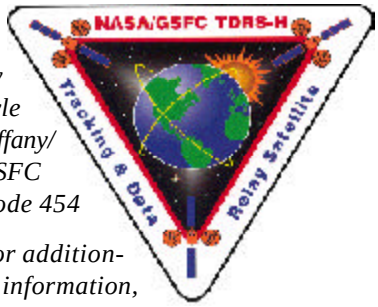
## TDRS-H Launch Update

The launch of the Tracking and Data Relay Satellite-H (TDRS-H) aboard the Atlas II A rocket from Cape Canaveral Air Force Station in Florida is now scheduled for late June.

TDRS-H, previously scheduled for a September 30, 1999 launch, was delayed due to launch vehicle problems associated with the RL10 engines and launch manifest changes. With restrictions lifted for the Atlas II A launch vehicle, the mission is targeted for a June 29, 2000 launch.

The new satellite will provide NASA's customer community (which includes the Space Shuttle, planned International Space Station, Compton Gamma Ray Observatory, Hubble Space Telescope, Terra Earth Observing System, and others) with improved communications capabilities, in addition to maintaining compatibility with the existing TDRS constellation. TDRS-H is the first of three satellites built for NASA by Hughes Space and Communications that will replenish the current, on-orbit fleet of TDRS satellites built by TRW. Following the launch, TDRS-H will be placed in geosynchronous orbit 22,300 miles above the earth at 150° W longitude for on-orbit acceptance testing of the satellite.

The TDRS Project Office at Goddard, under the direction of Anthony Comberiate, manages the TDRS H, I, J Replenishment Spacecraft Program.




*By Lyle Tiffany/ GSFC Code 454*

*For additional information, please contact the author at (301) 286-5678.*

## Rapid Spacecraft Development Office Rapid II Contract Awarded

The Rapid Spacecraft Development Office (RSDO) is pleased to announce that the Rapid II contract was awarded in December 1999. Rapid II, the successor to the Rapid Spacecraft Acquisition (RSA), is similar to its predecessor, but includes many improvements. Like RSA, Rapid II is an Indefinite Delivery Indefinite Quantity (IDIQ) contract with multiple awards. The Rapid II contract was awarded to six vendors who will offer a total of fourteen spacecraft buses. (For more information on the award process and a list of the winning vendors and buses, visit the RSDO on-line newsletter at *http://rsdo.gsfc.nasa.gov/newsletter/default.htm.*) Using Rapid II, customers searching for a satellite bus can hold "mini-competitions" between vendors and place an order for a satellite more quickly than if they used traditional acquisition processes.

Rapid II differs from RSA contracts in several ways, however, allowing the RSDO to provide increased service to our customers. Some of the changes and improvements in Rapid II include:

- an "on-ramp" allowing NASA to award new contracts and/or modify existing contracts to add additional core buses and options
- annual refreshment of core-bus technical details and options
- the ability to purchase vendor-provided Delivery In-Orbit
- the ability to purchase individual spacecraft components on an emergency basis

Rapid II contracts have a minimum value of $50,000 and a maximum value of $1.5 billion for cumulative delivery orders, with a five-year ordering period. Core bus payload accommodation capabilities range from 10 to 750 kg, and from 10 to 1000 watts. Baseline orbits include Low Earth Orbiting (LEO), Sun Synchronous, Geosynchronous Earth Orbiting (GEO), and Deep Space. The Rapid II baseline scope of work includes:

- spacecraft build and test
- interface control document generation and interface integration
- mission-unique modification design
- instrument integration and test
- environmental test
- shipment to launch site
- launch vehicle integration support
- on-orbit checkout.

These capabilities can be modified to meet individual mission needs. Non-baseline services which can be obtained from the spacecraft vendor when purchasing a bus include spacecraft operations, networks and mission operations, and launch services. Accommodation assessments (studies) can also be performed during the mission formulation phase to verify the capability of the contract buses to meet customer needs.

We at RSDO expect that Rapid II will continue the success achieved by the RSA contract, allowing us to provide a quicker, more efficient satellite procurement option to our customers.

*By Ron Miller/GSFC Code 456 and Sharon Collignon/GSFC Code 214.3*

*For additional information, please visit the RSDO homepage at http://rsdo.gsfc.nasa.gov or contact Jim Adams/RSDO Chief at jim.adams@gsfc.nasa.gov or via telephone at (301) 286-1289.*

## User Planning System Developing TDRS H,I,J Capability

User Planning System (UPS) personnel are busy enhancing the UPS software to create and process schedule requests specifying the new services available on TDRS H,I,J. This release, dubbed UPS 2000, will support all three new H,I,J services (S-band Multi-Access, Ka-band Single Access, and Ka-band Single Access Wideband) and is scheduled for deployment for the early fall of this year.

The UPS Release 12, which supports flexible scheduling features available with NCC 99.1, is available to all customers, and, by the time this article is published, should be in use by MultiSAT customers. Deployment of UPS Release 12 had been postponed due to the Year 2000 software freeze.

There is more good news–personnel at JSC are making use of new Hewlitt Packard (HP) equipment for their UPS system, which supports Shuttle and Space Station scheduling. The new UPS HP system supported STS-99 successfully in February 2000. Since the UPS on the HP system communicates with the NCC via TCP/IP, there are no longer any customers using the old Nascom Gateway, and all support for that gateway has been terminated.

*By Howard Michelsen / CSC / CSOC*

*Further information regarding the UPS Project can be found on the WWW at http://isolde.gsfc.nasa.gov/ups/ or contact the author via email at hmichels@cscmail.csc.com.*

## TCP/IP Services at the White Sands Complex

The White Sands Complex Transmission Control Protocol/Internet Protocol (TCP/IP) Data Interface Service Capability (WDISC) allows Space Network (SN) customers to send command data and receive telemetry data using TCP/IP. The WDISC system was officially delivered to Consolidated Space Operations Contract (CSOC) operations on May 1, 1999.

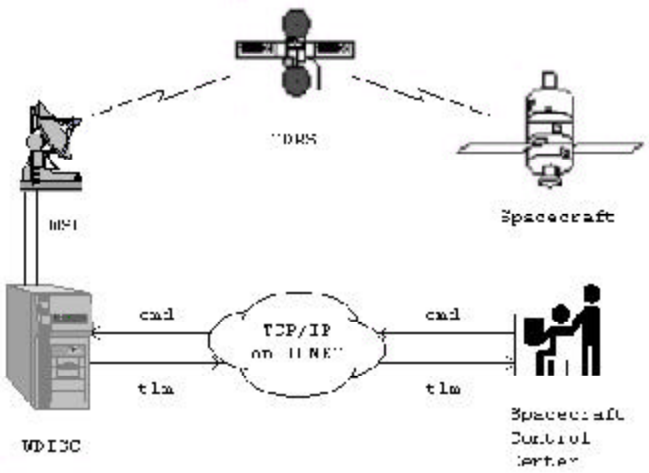
Three advantages of using WDISC over the legacy multiplexer/demultiplexer (MDM) delivery system are:

1) WDISC does not require a special conversion device on the customer's side. The MDM is a legacy system for low-rate SN data transfer. Data transferred on the MDM is formatted in 4800-bit blocks and then encapsulated in User Datagram Protocol (UDP)/IP packets. A conversion device is required on the customer's side to format and unformat MDM data.

2) The TCP/IP protocol used by WDISC allows for reliable delivery of data packets, whereas UDP/IP does not.

3) WDISC can provide several Consultative Committee for Space Data Systems (CCSDS) standards that are unavailable from the MDM, such as Reed-Solomon decoding of telemetry data.

WDISC supported its first customer with the launch of the Far Ultraviolet Spectroscopic Explorer (FUSE) mission on June 24, 1999. WDISC has provided FUSE support during 133 scheduled SN events, from launch through January 31, 2000. Future FUSE support is expected to total one or two events per month unless there is a contingency.




Customer Data Flow with WDISC

WDISC is currently testing with New Millennium Program/ Earth Orbiter-1 (NMP/EO-1), which is scheduled to launch in June 2000. Future customers will include Gravity Probe-B (GP-B), Microwave Anisotropy Probe (MAP), Thermosphere Ionosphere Mesosphere Energetics Dynamics (TIMED), and the Ultra-Long Duration Balloon Project (ULDBP).

WDISC has encountered no problems associated with the Year 2000 transition.

The figure shows data flow between a customer's spacecraft control center and its spacecraft using TCP/IP packets, the IP Operational Network (IONET), WDISC, the White Sands Complex (WSC), and a Tracking and Data Relay Satellite (TDRS).

*By John Groom/ATSC*

*For additional information on WDISC, please contact the author via email at John.R.Groom.1@gsfc.nasa.gov or via telephone at (301) 286-7799.*

## White Sands Complex News

The White Sands Complex (WSC) entered the new millennium with a yearly rating of "Exceeds the Level of Excellence," as defined in the WSC operations contract. WSC personnel are very proud of this accomplishment, and are actively investigating new approaches to raise WSC's performance even higher.

Personnel in the Software Maintenance Training Facility (SMTF) are studying modifications to enhance the reliability and performance of WSC's database software. WSC Engineers are modifying WSC's User Services hardware to support the communications standards of the old Ground Network (GN). Considerable support is being provided to new customers to ensure that their TDRSS interfaces perform flawlessly.

Installation of the Third Generation Beam Former (TGBF) is being performed at WSC and at the Guam Remote Ground Terminal (GRGT). After the installations are completed, the TGBF will allow WSC and GRGT to offer on-demand access to multiple access services.

WSC's security access control and monitoring system is presently being upgraded. WSC personnel discovered that the security system could have experienced some Year 2000 (Y2K) problems. A work around was developed, tested, and implemented prior to January 1, 2000. The new security system permanently resolved any remaining Y2K issues. WSC passed through the Y2K transition with no detectable problems.

The GN support capability, being added to the User Services, will enable WSC to offer support for satellites with only GN interfaces. The GN support will offer data rate, sub-carrier, and modulation compatible signal processing to the existing Modulator Data Predictors (MDP). The goal is to provide "backward" compatible support to prolong the useful life of GN-compatible satellites.

The WART (WSC Augmented Relay Terminal) has been successfully installed and is being used in normal operations. The WART will be enhanced, as needed, to augment the performance of the South Pole Terminal Relay (SPTR).

*By Douglas Perkins, WSC Training*

*For more information, please see the WSC Project Office home page at http://wscproj.gsfc.nasa.gov, or contact Jim Gavura, Station Director, or Bryan Gioannini, Deputy Station Director, at (505) 527-7000.*

The TDRSS Antennas at the White Sands Complex

## MMFDF Assists WIND with Pioneering Backflips

On February 2, 2000, the Multimission Flight Dynamics Facility (MMFDF) assisted the WIND spacecraft with its twenty-ninth flyby of the Moon, marking the completion of its second lunar backflip. WIND's historic first backflip, which occurred in April 1999, was the first ever attempted by any mission, proving that the previously theoretical backflip concept could be successfully incorporated into an actual spacecraft trajectory.

The first flyby of the backflip sends the spacecraft out of the ecliptic plane on a trajectory that intercepts the Moon again two weeks later (see Figure 1 below). The backflip rotates the orbital line of apsides by 180 degrees, and alters the orientation of the orbit apogees from nightside to dayside. Using conventional propulsion methods to maneuver the satellite in the same way would require more fuel than that of the entire WIND fuel budget!

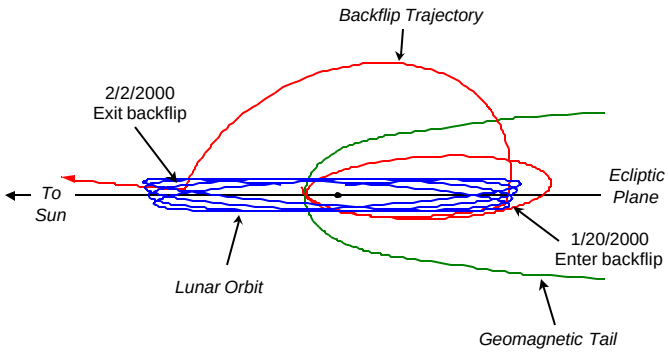



Figure 1. XZ Projection in Geocentric Solar Ecliptic (GSE) Coordinates

Since the backflip flybys occurred only two weeks apart, the trajectory was extremely sensitive to even the slightest perturbations; navigational errors could have jeopardized the mission, demanding correction maneuvers that exceeded WIND's current delta-V capacity. By executing several small maneuvers at strategic locations, however, MMFD personnel

*(continued on page 10)*

*(continued from page 9)*

were able to complete the backflip using only a few meters per second of delta-V, achieving lunar flyby coordinates within a few hundred meters of the predicted values.

In August 2000, WIND is scheduled to make history again by becoming the first spacecraft to fly in a Distant Prograde Orbit or DPO (see Figure 2, below). For two years, WIND will remain at distances between about 600,000 and 1,800,000 km from the Earth. With apogees aligned roughly along Earth's orbital track, WIND's DPO will enable scientists to obtain valuable measurements in the undisturbed interplanetary medium, which will be correlated with data from the Advanced Composition Explorer (ACE) spacecraft at the Sun-Earth L1 libration point for an unprecedented study of the solar wind.

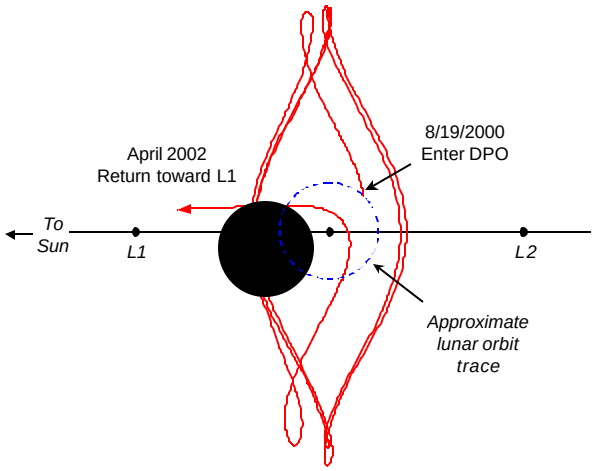



Figure 2. XY Projection in Geocentric Solar Ecliptic (GSE) Coordinates

For more on the WIND spacecraft and additional diagrams depicting the two backflips, see the WIND article on page 23.

*By Heather Franz/CSC*

*To obtain more information on this subject or other MMFDF matters, please contact Scott Wallace via email at Scott.wallace@gsfc.nasa.gov, or via telephone at (301) 286-5314.*

## It Wouldn't Be the Holidays Without a Shuttle Mission

During the December 1999 holiday season, the third servicing mission to the Hubble Space Telescope (HST) was successfully performed by the in-flight and ground crews of the STS-103/Discovery mission. GSFC's Multimission Flight Dynamics Facility (MMFDF) personnel supplied key HST and space shuttle Orbiter support for this mission.

For each launch attempt and the actual launch, MMFDF provided the necessary nominal launch and launch contingency acquisition data for both the Ground Network and the Space Network, and provided updated mission support products to the networks around the clock during the mission. Special HST attitude displays and products were generated and provided to the HST POCC and the HST Space Science Institute in support of the capture and release of HST, as well as for the astronauts' three extravehicular repair activities. The attitude displays were instrumental in validating the polarity of the newly installed gyros prior to the release of HST, and gave HST personnel a better insight into the exact status of the HST than they would have otherwise had. The most critical support services provided by MMFDF personnel were the determination of HST's post-release orbit and the generation of the new HST post-release ephemeris for uplink to its on-board computer. (For more information about the third HST servicing mission, see the article on page 15.)

MMFDF also provided special ephemeris data during the STS-103 landing to the X-33 Reusable Launch Vehicle Project. X-33 personnel used this data to point special cameras at Discovery in order to study the thermal characteristics of Discovery's surface during reentry. This thermal data will help guide the design of the X-33's external surface. Additional support provided by MMFDF during the STS-103 mission included Terra early on-orbit operations, (launched the day before STS-103) as well as KOMPSAT and ACRIMSAT mission support (launched during the STS-103 mission).

*By Pepper Powers/CSC and Romae Huntley/CSC*

*To obtain more information on this subject or other MMFDF matters, please contact Scott Wallace via email at Scott.wallace@gsfc.nasa.gov, or via telephone at (301) 286-5314.*

## SDPF Supports HST Servicing Mission

December and January were busy months for the Science Data Processing Facility (SDPF), located in Building 23 at the Goddard Space Flight Center. In addition to preparing for and successfully navigating the Year 2000 rollover, the SDPF supported the Hubble Space Telescope (HST) Servicing Mission 3A (SM3A), with the December 19, 1999 launch of STS-103 (for additional information on this mission, see the articles on pages 10 and 15). The SDPF supports HST by capturing and archiving raw HST data on the Generic Recording System (GRS), processing raw data into level-zero data products on the Packet Processor (Pacor) II system, and delivering science products to the science community from the Data Distribution Facility (DDF).

SDPF was involved in many pre-launch tests to prepare for the servicing mission and to plan for the data processing and delivery activities required during and immediately following the mission.

On December 22, 1999, the SDPF supported the SM3A Ku-Band On-Orbit Checkout by receiving, processing, and analyzing HST science dump data. On December 24 and 25, 1999, the SDPF supported the SM3A Solid State Recorder (SSR)-1/SSR-3 Functional Test by processing and analyzing HST data.

Following the completion of the servicing mission, the SDPF continued to support the Servicing Mission Orbital Verification (SMOV) by providing quicklook data sets of selected HST observations to the HST Science Institute. Fourteen such data sets were received, processed, analyzed, and delivered in an expeditious manner to facilitate the on-orbit verification of the servicing mission objectives.

Although SM3A was just completed, the SDPF is already beginning discussions with HST Project personnel concerning the next planned servicing mission, SM3B, currently scheduled for June 2001.

*By Brian Repp/ATSC*

*For further information, please contact the author via telephone at (301) 286-3699 or via email at Brian.D.Repp.1@gsfc.nasa.gov.*

# Mission Services Program Customers

## Terra Update

On December 18, 1999, the Terra spacecraft successfully launched aboard an Atlas-IIAS Expendable Launch Vehicle from Vandenberg Air Force Base (VAFB) in California. This launch was the first liquid hydrogen fuel expendable launch vehicle flown from VAFB. The instruments aboard Terra will collect data allowing scientists to study how the Earth's atmosphere, land masses, oceans, life, and radiant energy interact. Currently, the Flight Operations Team is performing the complex process of orbital verification, instrument turn on and calibration.

*For more information on Terra, please visit the Terra web site at http://eos-am.gsfc.nasa.gov*

The Terra Spacecraft Aboard the Atlas-IIAS Launch Vehicle

# The Compton Gamma Ray Observatory Mission May Continue Despite Gyro Loss

The Compton Gamma Ray Observatory (CGRO) is now well into its ninth year in orbit, following its April 1991 launch by the space shuttle Atlantis. It continues to collect valuable scientific data, with three of the four scientific instruments performing at essentially their post–launch level of efficiency. A recent hardware failure involving a component of the attitude control system, however, threatens the future of the CGRO mission.

In December 1999, one of the three gyroscopes was shut down as its current level went above limits. Attempts to power it back on failed, and the observatory went into safe-hold mode. This particular failure mode had long been anticipated, as the gyro currents had exhibited greater than normal fluctuations and a gradual increase. There is a large degree of redundancy engineered into the CGRO spacecraft; each gyro provides spatial references relative to two orthogonal spacecraft axes. In addition, absolute spatial references are provided by a magnetometer and a fine-sun sensor.

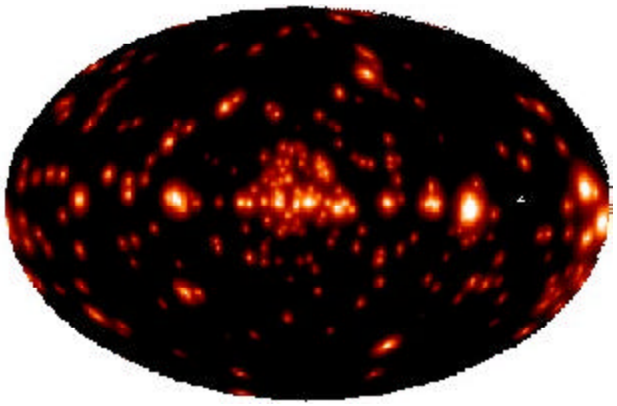
The flight operations and spacecraft analysis teams were thus prepared to uplink a two-gyro based attitude control system, which had already been extensively tested on the Goddard CGRO flight simulator. Within a short period of time, the two-gyro system was tested on the spacecraft, found to be working satisfactorily, and science operations were resumed. In retrospect, the net loss of science time was remarkably minimal for a failure of this magnitude.

Some problems, nonetheless, remain. At the time of the gyro failure, there was no well-developed contingency plan for operating the spacecraft in the event of an additional gyro failure. Despite the fact that there is no evidence that either remaining gyro is in imminent danger of failure, this is viewed as a major concern. CGRO is the most massive scientific payload ever deployed by the space shuttle—its ground weight being 17 tons. A longstanding requirement for the mission is that at the termination of science data collection, the spacecraft be either retrieved by the space shuttle, or a controlled reentry maneuver be performed, since portions of the spacecraft will almost certainly survive reentry, posing a potential danger. Without a one-gyro (or zero-gyro) backup attitude control system, an additional gyro failure would necessitate the far more expensive, and possibly implausible retrieval option. Thus, at the time of this submission, consideration is being given to an early termination of the mission.

The good news, however, is that there now appears to be a viable one-gyro (or zero-gyro) backup plan, which is now being extensively studied for feasibility on the simulator. This plan entails placing the observatory into a 1-RPM spin about its inertial symmetry axis—i.e., the axis about which its moment of inertia is greatest. This axis also corresponds, not coincidentally, to the thrust axis along which the Orbit Adjust Thrusters (OATs) are aligned. This will provide a definitive spatial reference. A series of thruster burns at specific points within the orbit will then decrease its perigee, leading to safe reentry over the Pacific ocean.

There are still a number of complications which need to be addressed. For example, a failure of part of the propulsion system early in the mission has rendered two of the four OATs questionable. Only the other two fully functional OATs have ever been used for orbit maintenance. Nonetheless, clever strategies have been devised to perform the reentry maneuver with the two reliable OATs. Some additional uncertainties remain, but none seem to be "show stoppers" at the moment, so there is considerable optimism that the mission can be continued.

Meanwhile, CGRO continues to collect unique and valuable scientific data. For example, recent results have emerged suggesting the existence of a previously unrecognized population of galactic gamma-ray sources. A venerable issue in gamma-ray astronomy has been the nature of the high-energy gamma-ray sources along the Galactic plane. The Energetic Gamma Ray Experiment Telescope (EGRET) on CGRO has provided a much cleaner map to work with, having approximately 170 resolved point sources. Yet, not only does the mystery remain, there is now a new twist to the old problem. A recent analysis suggests the presence of an enigmatic second sub-plane population of the Galactic plane sources. These sources are characterized by intermediate latitudes (between 5-30°), and lower intensities and distinct spectra from the general Galactic plane population spectra which seem to be systematically softer (see figure below).



EGRET Sources Based on Emission Above 100 MeV

Furthermore, there is no evidence of source variability, which argues against the possibility that these sources are background, extra-galactic gamma-ray quasars, since those are known to be highly variable.

In the image, the population in question is evident as the fainter subset of sources, notably the clustering above the Galactic center region. A statistically significant association of this population with the well known "Gould's Belt"—a distribution of massive stars and molecular clouds in an approximate sinusoid about the plane—has been demonstrated. Possibilities for gamma-ray production mechanisms include super-novae remnants; cosmic ray interactions with molecular clouds; or young, hot stars whose intense winds interact with an ambient interstellar medium. The more general Galactic population, centered closer to the plane, is likely to be dominated by pulsars, but this is still an open issue.

It is hoped that with the dedicated support of the CGRO operations support staff, and a little bit of luck, the mission can be continued into its second decade, and more new results will be forthcoming.

*By Chris R. Shrader/CGRO Science Support Center, GSFC*

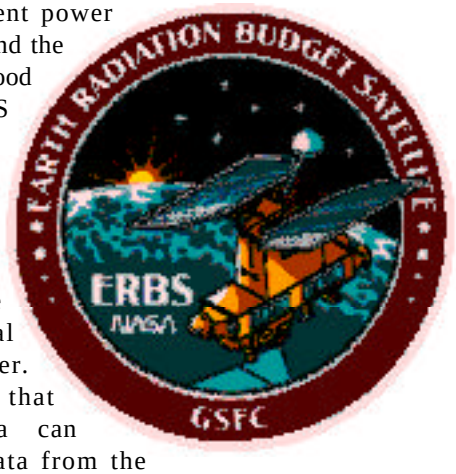
*For additional information refer to "http://cossc.gsfc.nasa.gov" on the World Wide Web.*

## ERBS Team Responds to Battery Anomaly

On October 5,1999, the Earth Radiation Budget Satellite (ERBS) marked 15 years of operations. Despite several significant failures, ERBS continues to collect valuable science data from its two remaining instruments, the Earth Radiation Budget Experiment Non-Scanner (ERBE-NS) and the Stratospheric Aerosol and Gas Experiment (SAGE-II). SAGE-II, which monitors the vertical distribution of stratospheric aerosols, ozone, nitrogen dioxide, and water vapor, continues to function normally and to collect approximately 99% of available science data.

The ERBE-NS, which provides readings of solar absorbed radiation and emitted thermal radiation, recently experienced an anomaly. After a routine calibration the instrument failed to slew back to its nominal operating position. It was found, however, that the instrument is very close to where it should be and that the science data is not impacted. Thus, the data recovery rate remains excellent, but calibrations have been replaced by solar measurements to avoid moving the instrument from its current position.

In January 1999, due to multiple cell failures, Battery #2 (which had been providing sole power to ERBS for 5 years) could no longer support operations. The decision was made to switch to Battery #1, which had been taken off-line in August of 1992. This risky operation proved successful, and Battery #1 has been supporting the entire spacecraft power load for over a year now. Every January ERBS goes through a period of Full Sun, where the satellite does not pass through the earth's shadow. During this period the battery can easily overcharge. January Full Sun, 1999 was the main cause of two cell failures on Battery #2. In January 2000, ERBS, using Battery #1, survived Full Sun without any problems. Should problems eventually arise, the ERBS flight operations team will be able to identify and respond to them more quickly than in the past, thanks to a new offline analysis system, which is in the final stages of development.




With the current power configuration and the instruments in good shape, ERBS should be able to continue collecting valuable science data on our atmosphere and on global energy transfer. The hope is that SAGE-II data can overlap the data from the several SAGE-III instruments slated to be launched on missions in the next several years.

*By Sabina Bucher/ATSC*

*For more information contact the ERBS Mission Director, Robert Sodano (GSFC Code 581) at (301) 286-6506.*

# EUVE and the Final Push To/Through Y2K

Ushering in the year 2000 ended an era and began a new one. Yet, in a time-independent fashion NASA's Extreme Ultraviolet Explorer (EUVE) mission at the University of California at Berkeley (UCB) continued to churn out exciting science and push the limits of satellite operations.

First, and foremost, the EUVE observatory continues to be highly productive scientifically. For example, Dr. Casey Lisse (University of Maryland) released his data analysis results from the EUVE observation of Comet 2P/Encke during its July 1997 close approach to Earth. The combined EUVE and ROSAT imaging data show extended variable emission on the sunward side of Encke's nucleus. While the emission morphology is similar to that seen in Comet Hyakutake, the source of this variable emission is very different, and is helping scientists better model and understand the actual EUV emission mechanisms.

In addition, Dr. Randy Gladstone (Southwest Research Institute) released the analysis results of the April 1998 EUVE observation of Venus, which posed an extreme technical challenge for the EUVE Flight Operations Team (FOT) (see the previous *Integrator* article in Vol. 7, No. 1). The resulting data comprise the first full EUV spectrum of Venus (see Figure 1) and show obvious emission lines of helium and oxygen. Dr. Gladstone is using these data to model and simulate the Venus "dayglow" (see Figure 2). More on these and other EUVE science highlights are available on-line at *http://www.cea.berkeley.edu/~science/html/Resources_high.html*.

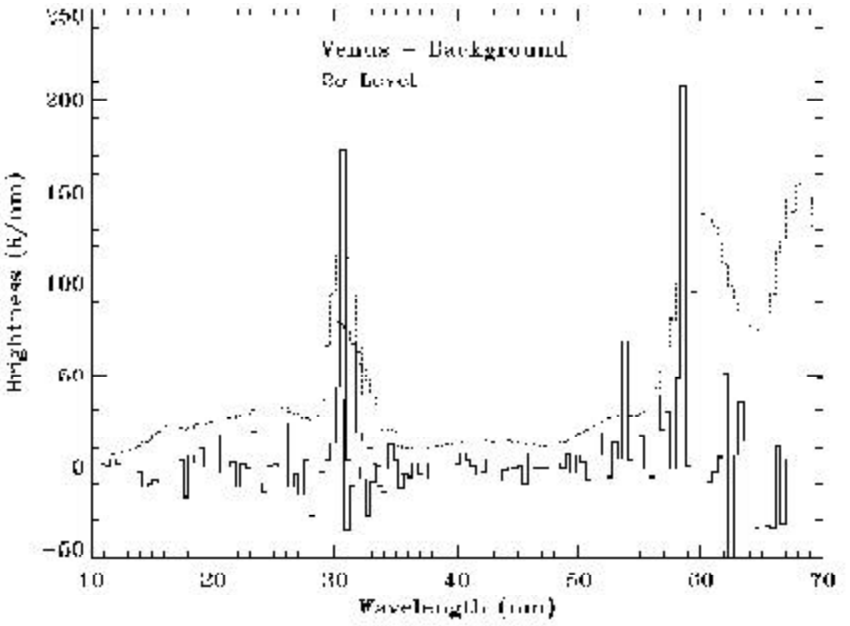
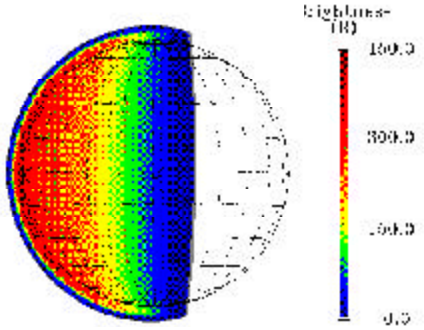



Figure 1. EUVE Emission-line Spectrum of Venus

In order to facilitate future discoveries, in October 1999 the EUVE Project released preliminary results of some recent science calibration observations. These results indicated that six of the seven EUVE instrument systems continue to be very stable and show no significant degradation. The long-wavelength spectrometer instrument, however, did show significant response degradation, most of which should be correctable by adjusting some on-board parameters.

Figure 2. Model of Venus EUV "Dayglow" Emission



Sub-Solar Longitude = 50.7 Sub-Earth Longitude = 131.1
Sub-Solar Latitude = 0.6 Sub-Earth Latitude = -1.0
Average Brightness over Sunlit Fraction = 219.8 R

But science is not the only activity for the EUVE Project at UCB; the FOT continue to be very busy in a multi-tasking environment. During the past few months EUVE retained its ~99% science data return rate while conducting 37 separate pointings of 15 celestial targets. A few of these observations were notably interesting from an operations viewpoint. Coordinating with the Galileo flyby of Jupiter, EUVE conducted an observation of the Jupiter-Io plasma (one-slew-per-day) on October 5-20, 1999. EUVE also observed the late-type star Procyon, accomplishing the third of four scheduled cross-calibration observations with the Chandra X-ray Observatory (CXO). We also placed EUVE in a safe attitude orientation for two hours to ride out the Leonid meteor storm in November, and conducted a 34-day observation of the active galaxy Ton S 180, in

conjunction with the Advanced Satellite for Cosmology and Astrophysics, Far Ultraviolet Spectroscopy Explorer, Hubble Space Telescope, and Rossi X-ray Timing Explorer.

The past few months have not, however, been without incident. On 22 December 1999 EUVE entered Safe-Hold Mode (SHM) as a result of very high differential voltage (dV) levels in one of the three on-board batteries (Battery #3). This SHM event occurred just after the FOT had started to recondition the batteries in order to mitigate the problem. The FOT quickly verified overall system health and brought the systems back on-line. Battery #3 was reengaged into the recharge cycle, and the reconditioning was completed the next day. The FOT is reconditioning the batteries on a monthly basis in order to more actively manage Battery #3, which seems to be slowly developing a "short" and may not last much longer. Each reconditioning has resulted in improved battery performance. Loss of a single battery will not pose any significant threat to the mission, as EUVE can operate fully on only two batteries.

On 22 January 2000, the science payload exhibited an anomaly of a type we have never before seen. An analog-to-digital (ADC) converter got locked into a strange state in which it would not properly process photons from one detector. This anomaly was discovered by hand a few days afterward. The particular ADC engineering monitor was not automatically checked by ground telemetry monitoring software, since it routinely takes on all possible values for brief periods of time. The FOT cleared the anomaly by resetting the affected telescope software. The underlying cause of the anomaly remains a mystery and is under investigation, and the FOT is also working to determine an indirect way to automatically monitor for these types of incidents in the future.

And then there was the Year-2000 (Y2K) transition. During the last few months of 1999 the EUVE Project, in collaboration with spacecraft support software teams at GSFC, completed its Y2K efforts for all mission-critical systems. In late December, as a precaution for any possible long-term Y2K-related communications outages, the FOT uplinked a new on-board automated monitoring and command sequence to protect the high-gain antenna gimbals from overheating, which has been a problem in the past. At the magic hour on 31 December, without major incident, the EUVE flight and ground systems smoothly transitioned to the year 2000. Thanks go to the EUVE team at UCB and to the support personnel at GSFC who together ensured that the dreaded Y2K transition occurred smoothly and successfully.

In addition, the FOT continued to provide part-time engineering support for a number of other missions. We assisted the Fast Auroral Snapshot Explorer (FAST) mission, as it successfully completed the outsourcing of its operations from GSFC to UCB in October 1999. EUVE has also been providing engineering support for the integration and test activities for UCB's Space Science Laboratory's High Energy Solar Spectroscopic Imager (HESSI) mission, which is scheduled to launch in July 2000. We expect to continue providing this support at least through launch and early orbit activities.

Finally, the EUVE Project has begun networking with other missions to share ideas and lessons learned. In October 1999 representatives from the Voyager and Ulysses missions at NASA's Jet Propulsion Laboratory traveled to UCB to visit with EUVE engineers to exchange ideas, discuss operations issues, and review the EUVE setup. EUVE Project personnel plan to travel to GSFC and elsewhere during the upcoming months, and strongly invite and encourage any missions interested in holding similar discussion with us to please contact the author at the address below. For more information on EUVE mission operations activities please see the monthly highlights that are available on-line at *http://www.cea.berkeley.edu/~pubinfo/html/EUVE_operations_high_ opshigh.html*.

*Article by Brett Stroozas / EUVE Project/Mission Manager*

*For more information, please visit the UCB/CEA WWW site at URL http://www.cea.berkeley.edu, or contact the author at (510) 643-7312 or via e-mail at bretts@cea.berkeley.edu.*

## All Systems Are "Go" for the Revamped Hubble Space Telescope

Since our last article, the Hubble Space Telescope (HST) has completed its internal simulations, wrapped up its Joint Integration Simulations (JISs), lost a gyro causing a interruption of science data, added an additional JIS to practice capture with the shuttle, and finally completed Servicing Mission 3A (SM-3A) in December 1999.

The HST ground teams at both the Goddard Space Flight Center (GSFC) and the Johnson Space Center (JSC) had already completed their respective internal simulations and JISs, when the HST experienced another gyro failure in late October, causing several critical events. The first and most

*(continued on page 16)*

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important was the interruption of science data. The second was the change in attitude control, which necessitated a change in the capture plans with the shuttle. An additional JIS had to be scheduled to practice the new method of capturing the HST.

The HST ground team was able to both support normal operations in a safemode status, and practice the critical capture events. These events included changing the status of equipment onboard to a non-nominal state so the HST attitude could be held as stable as possible to provide a steady target for the orbiter. In addition, Fine Guidance Electronics (FGE) had to be turned off prior to entering Hardware Sun Point Safemode, and the Retrieval Mode Gyro Assembly turned on. An on-orbit test of the hardware sunpoint mode was executed to gain operational experience with this mode using the backup retrieval mode gyro assembly.

On December 19, 1999, the shuttle Discovery launched at 7:50pm EST. With successful completion of the critical mode changes, the HST was grappled at 7:34pm EST on December 21. During the first Extra Vehicular Activity (EVA), astronauts successfully installed the Voltage Improvement Kits (VIKs) and Rate Sensor Units (RSUs). In addition, they successfully executed aliveness and functional tests on the newly installed equipment. That first EVA was the second longest in shuttle history at 8 hours and 15 minutes.

The second EVA involved the installation of a new computer. Astronauts replaced the legacy DF224 with a new 486-based machine. In addition, they installed a refurbished Fine Guidance Sensor (FGS). The third and final EVA included the installation of an Optical Control Electronics (OCE) cable, replacement of an S-Band Single Access Transmitter, replacement of an Engineering Science Tape Recorder (ESTR) with a Solid State Recorder, and installation of New Outer Blanket Layers (NOBLs) for Bays 9 and 10. Astronauts successfully conducted aliveness and functional tests on the equipment installed during these two EVAs also. The HST was released back on orbit at 7:03pm EST on December 25. It is interesting to note that this servicing mission was so popular with the public, that the HST web site received more than 1.5 million hits daily during the mission.

The HST returned to normal operations by Monday, December 27. Normal operation started with delivery of a new Science Mission Specification (SMS) from the Science Institute in Baltimore, initiating the Servicing Mission Orbital Verification (SMOV) activities. The majority of SMOV activities were completed by the end of January 2000, and all new equipment is functioning normally. The only activity remaining to be done is preparation of the FGS for use in guiding the spacecraft.

This SM-3A mission was very dynamic. Changes in the shuttle launch dates caused significant impacts to the Servicing Mission Integrated Timeline (SMIT), including the method of capturing HST, reduction in the number of EVAs from four to three, revision of the content of those EVAs and the order/priority of the EVA activities, and finally the release of the HST.

During the SM-3A the GSFC control center received many visitors and letters. A group from a school representing the Peanut Butter and Jelly Journal interviewed control center personnel. Local TV had both live and taped interviews with control center staff members. The GSFC Center Director and his family visited, speaking with the Mission Operations Manager (MOM) on console. Finally, letters of thanks citing a job well done were received from our U.S. Senators and Congressional Representatives.

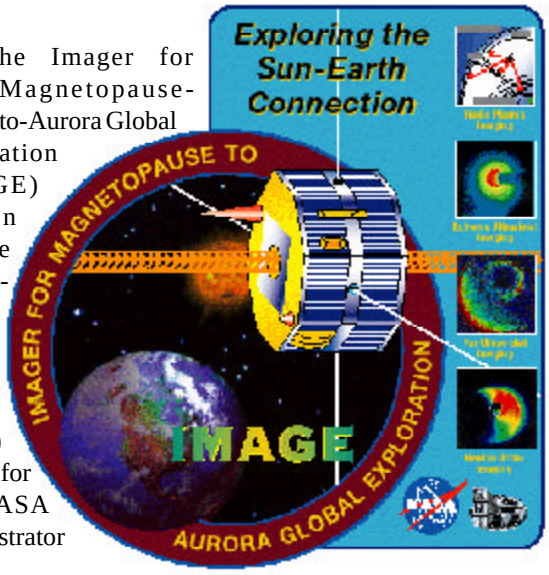
The HST Project would like to thank all the GSFC in-house support, the JSC, and Kennedy Space Center (KSC) support. Without this valued threesome, the internal simulations, JISs, SM-3A, and SMOV could not have attained success.

THANKS TO ALL!!!!

*By Art Hughes/GSFC Code 583*

*For additional information, please visit the HST web site at http://hubble.gsfc.nasa.gov.*

## IMAGE Is Prepared for Launch




The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission is at the Vandenberg Air Force Base (VAFB) waiting for the NASA Administrator

appointed Red Team's approval for launch. The current planned launch date for IMAGE is March 2, 2000. The IMAGE Spacecraft is currently ready for integration with its Delta II launch vehicle.

The IMAGE mission is the first satellite dedicated to imaging the Earth's magnetosphere—the region of space controlled by the Earth's magnetic field, and containing extremely tenuous plasmas of both solar and terrestrial origin. Invisible to standard astronomical observing techniques, these populations of ions and electrons have traditionally been studied by means of localized measurements with charged particle detectors, magnetometers, and electric field instruments.

Instead of such in-situ measurements, IMAGE will employ a variety of imaging techniques to "see the invisible," and to produce the first comprehensive global images of the plasma populations in the inner magnetosphere. With these images, space scientists will be able to observe, in a way never before possible, the large-scale dynamics of the magnetosphere and the interactions among its constituent plasma populations. IMAGE will deploy radial antennae 250 meters in four directions to aide in accomplishing its science goals, earning it the nickname the "cosmic weedwacker."

*By Wayne Gustafson/GSFC Code 568/IMAGE Mission Operations Manager*

*For additional information, please see the IMAGE Internet home page at http://image.gsfc.nasa.gov, or contact the author at wgustafs@pop700.gsfc.nasa.gov.*

Assembly of the IMAGE Spacecraft

## Successful Landsat-7 Imaging Mission Continues

Landsat-7 (L-7) continues to operate extremely well. It was launched on April 15, 1999 and entered the operational mode on July 15, 1999. It has been placed on the Landsat World Wide Reference System ground track, acquiring scenes in a 16-day repeat cycle, 8 days out of phase with Landsat-5. The Earth Science Mission Operations (ESMO) Project has been delegated lead responsibility for Landsat-7 operations by the Earth Observing System-G (EOS-G) Program Office.

L-7 operations are multifaceted. The U.S. Geological Survey (USGS) is an equal partner with NASA in the program. All U.S. L-7 data are either acquired at, or shipped on tape to the USGS's EROS Data Center (EDC) for processing, archiving, and distribution. In addition, EDC has agreements with International Cooperators to directly downlink data to their ground stations. Presently, we are downlinking to ten stations belonging to six international cooperators. Within NASA, L-7 uses the EOS Polar Ground Network (EPGN) to acquire science data; uses both the EPGN and TDRS networks for housekeeping and tracking; and also uses services at the EDC, provided by the EOS Data and Information System, for archiving and data distribution. In addition, the Landsat Project Science Office provides calibration updates, sponsors the Landsat Science Team, and works in conjunction with the L-7 Image Assessment System folks at EDC to perform radiometric and geometric analyses.

Landsat-7 has been acquiring, processing, and archiving images per its Long Term Acquisition Plan. As of the first of February, approximately 45,000 images have been placed in the U.S. archive at EDC. Cloud cover prediction tools have been working very well because, on average, each image in the archive is two-thirds cloud free, whereas images from earlier Landsat missions were only 50% cloud free. L-7 has imaged 90% of the Earth's landmass, including the polar regions, at least once.

Imaging over Antarctica started earlier than planned to check and adjust gain settings, preventing sensor saturation by bright snow and ice. Quality images of cloud free areas are being acquired during our planned Antarctic imaging season of January and February. East Antarctica has been relatively clear and western Antarctica has been cloudy. Acquisition priorities have been adjusted to concentrate on getting relatively cloud-free images of the coast and peninsula area. Approximately 95% of Antarctica, which consists of over 3600 scenes, has been imaged.

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There is a Landsat-7 Image Gallery available on the web at*http://landsat7.usgs.gov*.

Future Landsat 7 events include:

- Science Team Meeting
  May 9-11 – Boulder, CO
- LTWG #8 Meeting
  June - Ottawa, Canada
- SPIE Conferences, 2 Landsat-7 sessions
  April 24-28 - Orlando, FL
- SpaceOps 2000, Landsat-7 Scheduler paper
  June 19-23 - Toulouse, France
- IEEE Geoscience and Remote Sensing Society 2000, two LTAP papers and 2 LTAP posters
  July 24-28 – Hawaii

*By Ken Dolan/GSFC Code 430*

*For further information about Landsat-7, please visit the Landsat-7 home page at http://geo.arc.nasa.gov/sge/landsat/landsat.html, or contact the author at (301) 286-7962 or via email at Stephen.K.Dolan.1@gsfc.nasa.gov.*

## Unique IMP 8 Longevity Enables Science

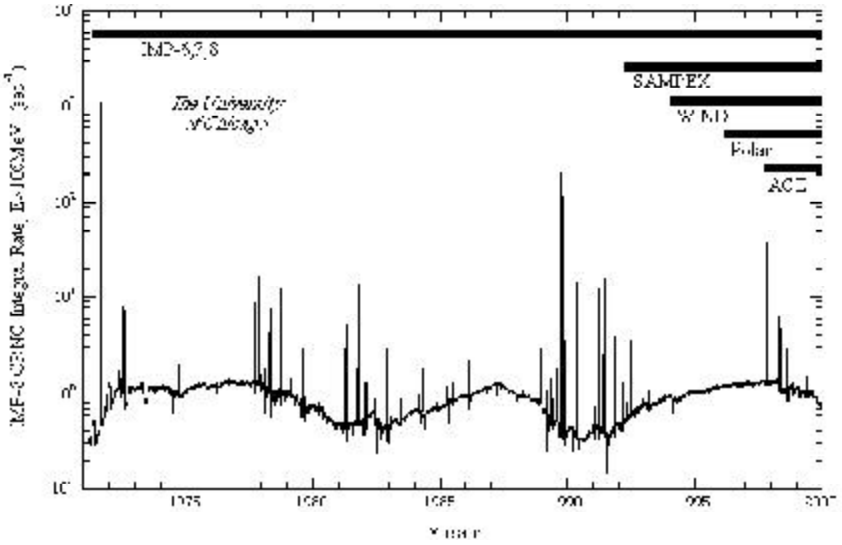
The IMP 8 spacecraft, launched in October 1973, continues to play an important role in conjunction with more recently launched spacecraft. For example, IMP 8 supports the International Solar and Terrestrial Physics program (WIND, POLAR, etc.) in the study of how the Earth's magnetosphere responds to changes in the nearby solar wind. (For more information on the WIND and POLAR missions, see article on page 23.) IMP 8 also supports deep space spacecraft (e.g., Voyager, Ulysses) in the study of interplanetary-scale behaviors of cosmic rays and of the solar wind.

One range of studies, however, is enabled and made more reliable by the longevity of IMP 8. It is customary for scientists to exploit operational overlaps between subsequent spacecraft, cross-normalizing data to build long term, multi-spacecraft data sets for long term science studies (for instance, to determine how the sun and its output vary over tens of years). It is preferable, however, to have single-source data when possible, thereby avoiding the potential data offsets cross-normalizations might introduce.

The figure below shows a plot of nearly 30 years of fluxes of very energetic protons observed by the University of Chicago cosmic ray detector on IMP 8. Visible is a line varying gradually, with a periodicity near 10 years and a series of spikes. Both of these features are very significant. The slowly varying component shows how cosmic rays coming toward Earth from the galaxy are affected (resisted) by the outflowing solar wind, which itself varies with the eleven year solar activity cycle.

The spikes are "solar energetic particle events" of a few days duration each. These are protons accelerated by solar flares and/or by interplanetary shock waves associated with explosive coronal mass ejections. It is these events that mission planners, especially those associated with manned missions beyond the relative safety of the Earth's magnetosphere, need to take into account in planning mission and human safety.

The Longterm Cosmic Radiation and the Largest Solar Events



IMP 8's longevity has allowed scientists to reliably determine the relative sizes of the various solar particle events, and to discover that variations in the galactic cosmic ray fluxes are associated with solar wind changes and not with a shift from one source spacecraft to another.

The longevity of IMP 8, on the other hand, is the result of excellent pre-launch engineering and of the post-launch ingenuity of the many Goddard personnel, who have been associated with IMP commanding, telemetry capture, and ground data processing over the years. Many ground systems that were "leading-edge" when IMP was launched twenty-seven years ago have subsequently become obsolete and not maintainable. New approaches and systems have been introduced in these areas.

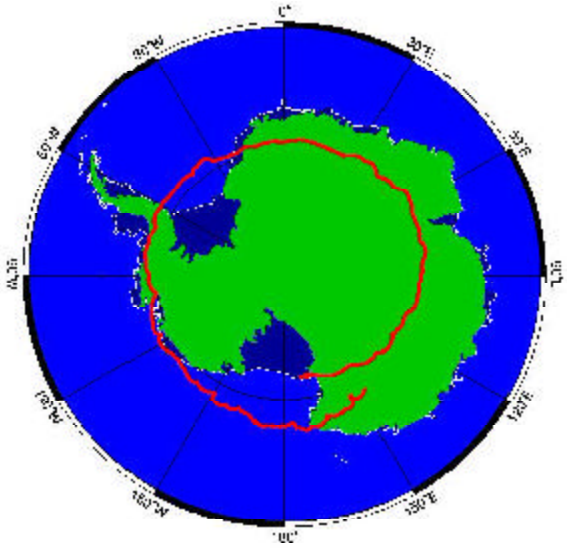
The space science community, benefiting greatly from IMP's longevity, owes much to the Goddard staff who enable IMP's continuing operability in the face of much technology turnover.

*By Dr. Joseph King/GSFC Code 633*

*For more information, please visit the IMP web site at http://nssdc.gsfc.nasa.gov/space/imp-8.html or contact the author via email at King@nssdca.gsfc.nasa.gov.*

## Flawless Mission for the Long Duration Balloon Program!

The Long Duration Balloon Program (LDBP) conducted another very successful flight from McMurdo Station, Antarctica. The payload was launched on January 11, 2000 and was terminated on January 30, 2000 on the polar plateau. The duration of the flight was just short of 19 days. The complete payload has not been recovered at this time, but the pressure vessel containing the archived science data and the TDRSS transponder have been retrieved. The flight was a complete operational and scientific success.



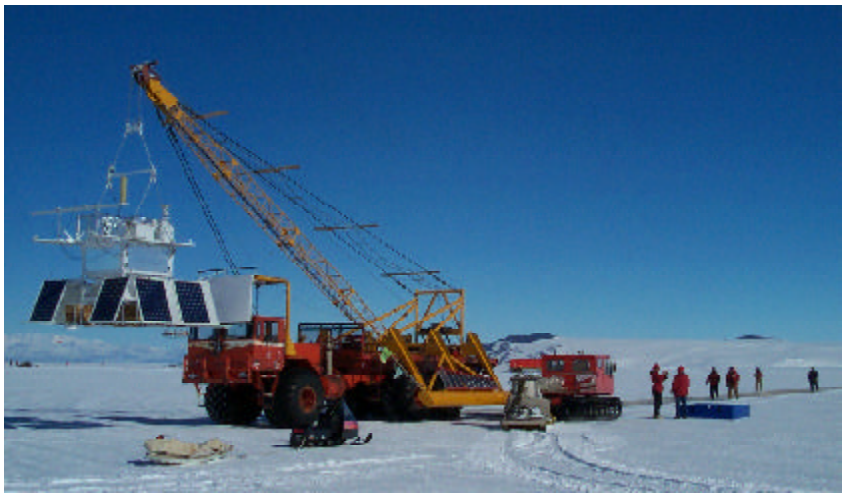
The Track of the January 2000 Antarctica Flight

The scientific experiment flown was a collaboration between the University of California at Berkeley and the University of Washington. Their detectors studied auroral X-rays in the MeV range. The science team reports that there were some high energy events observed during the flight which were relayed through TDRSS. Given the long duration of the flight, they will be analyzing this data for some time.

The LDBP expects to have two flights in Antarctica in December 2000 as well as two flights in Australia in January 2001.

*By Bryan Stilwell/NSBF/Physical Sciences Laboratory, NMSU*

*For additional information, please contact the author at (903) 723-9097 or via email at Stilwell@master.nsbf. nasa.gov.*



LDBP Payload on Launch Vehicle

## Tropical Rainfall Measuring Mission: Spring 2000 Status

The Tropical Rainfall Measuring Mission (TRMM) spacecraft remains in good health, and daily operations continue without mishap. The flight team weathered the Leonid meteor storm and the Year 2000 rollover quietly. We maneuvered the spacecraft to an altitude about 1 Km higher than usual on 29 December 1999, so that the following Delta-V maneuver would not occur on the January 1 weekend. In this way, the impact of potential communications problems was minimized, and in fact, none were experienced.

The flight team worked a number of software changes recently. We installed a change to our load shed scenario in January 2000, and reviewed and tested a power system software patch. In addition, several onboard command sequences relating to launch operations were zeroed out to free up additional space on that portion of memory.

Lastly, the flight team supported activity related to the Visible and Infrared Scanner (VIRS) instrument. In an effort to improve the quality of one of its data channels, instrument blackbody temperatures have been maintained between 9 - 16 degrees C. The quality of data on its Channel 4, the long wave spectral range channel with a wavelength of 10.80 micrometers, has shown remarkable improvement. A science data processing update set for autumn 2000 will permanently institute this improvement.

Upcoming events for TRMM consist of various software changes to onboard and ground system applications. In addition, the Cloud and Earth Radiant Energy Sensor (CERES) instrument is to be powered on late in February to gather data in parallel with a similar instrument onboard the recently launched Terra spacecraft. The plan is to have CERES remain on indefinitely once this effort begins.

Science data collection activities continue in excellent fashion. In this issue of *The Integrator* the VIRS instrument will be showcased. VIRS, as stated above, is a cross-track scanning radiometer which measures scene radiance in five spectral bands in the visible through infrared spectral regions. Able to more accurately estimate precipitation, VIRS also serves as a background imager, providing cloud context within which passive microwave and radar observations are made. Its data is used in rain estimation algorithms based primarily on passive and active microwave sensors.

Located on the +X (cold) side of TRMM, VIRS is secured to the Upper Instrument Support Platform. VIRS consists of a radiative cooler, solar calibration door, Earth panel and solar panel shields. The last two block Earth reflection and direct sunlight respectively. All of the above are housed in two sections—a scanner and an electronics module. Scanner dimensions are 43x80x46 cm with a weight of 23.3 kg. The electronics module is 32x23x22 cm and weighs 12.5 kg.

Commanding of this instrument is minimal. Every 3-4 weeks, a solar calibration request is received, consisting of commands to open/close the solar calibration door. Each request is placed in the daily command load so that it will execute at the desired time without the need of a Space Network real-time event. Otherwise, VIRS is always in its Mission mode for nominal data collection.

*By Lou Kurzmiller/TRMM FOT*

*For additional information, please visit the TRMM web site at http://trmm.gsfc.nasa.gov, or contact John Grassel/ ATSC by telephone at (301) 805-3167 or via email at john.grassel.1@gsfc.nasa.gov.*

## TOPEX/Poseidon Images Reveal Possible Long-Term Ocean Changes

The U.S.-French TOPEX/Poseidon satellite continues to provide scientists with exciting and unique measurements of sea surface conditions worldwide. The satellite bus and instruments remain in good health, as the mission moves towards completion of its eighth anniversary this summer. Although TOPEX/Poseidon has become well known for providing El Niño and La Niña images of the Pacific, some new and interesting observations have recently been enabled by the satellite altimetry data.

Project scientists at the Jet Propulsion Laboratory in Pasadena are studying the latest data from TOPEX/Poseidon which show a giant "horseshoe" pattern of higher than normal sea-surface heights in the western Pacific and Asiatic oceans. A cool wedge of lower than normal surface heights is also now becoming a dominant feature in the eastern equatorial Pacific. These conditions may be indicative of a decade long pattern known as the "Pacific decadal oscillation."

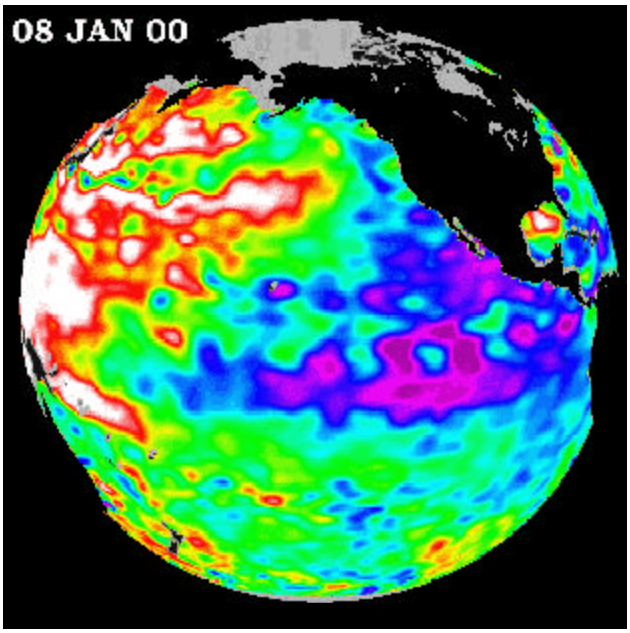
This developing condition has significant implications for global climate change, particularly over North America, according to JPL research oceanographer Dr. William Patzert. Dr. Patzert says that "The persistence of these abnormally high and low Pacific sea-surface patterns, along with warmer and colder than average ocean temperatures, tell us there is

much more than an isolated La Niña occurring in the Pacific Ocean. These warmer and cooler than normal sea-surface temperatures influence our atmosphere every day, while sea-surface heights are a measure of how much heat is stored in the ocean below. When you put these two pieces of the climate puzzle together, they will tell us both about what is influencing today's weather and how much heat is being stored in the ocean to fuel future planetary climate events."

The oscillation follows a 20 to 30 year pattern, during which the areas of warm and cool water alternate between what is presently being observed and the opposite condition, which reverses the warm and cool regions in the Pacific. Dr. Patzert cautions that it is premature to definitively label these observations as a strong, multiple-year Pacific decadal oscillation. However, it is expected that over the coming years TOPEX/Poseidon and Jason-1 (the TOPEX/Poseidon follow-on altimeter mission) will continue to monitor the development of this and other events such as El Niño and La Niña, and their potentially significant impacts on the Earth's climate.

*By Mark Fujishin/Mission Manager, TOPEX/Poseidon Project*

*More information about the TOPEX/Poseidon spacecraft is available on the WWW at http://topex-www.jpl. nasa.gov, or contact the author via email at mark.fujishin@jpl. nasa.gov.*




Recent image developed from TOPEX/Poseidon altimetry data, which displays the warm water "horseshoe" pattern (lighter areas) in the western Pacific, contrasted with the large cooler areas (darker) in the eastern regions. These observations may be early indications of a "Pacific decadal oscillation."

## UARS Experiences Tape Recorder Anomaly

The Upper Atmosphere Research Satellite (UARS), launched in September 1991, is equipped with two Narrow Band Tape Recorders (NBTRs), A and B. Nominal tape recorder operations utilized an alternating recording sequence such that one NBTR is recording at all times, with one recorder dumped once every orbit. Nominal recording is done in a 8-Mux Mode, recording from Beginning-of-Tape (BOT) to End-of-Tape (EOT) only. A backup 4-Mux Recording Mode is available recording from BOT to EOT on channels 1 to 4 (Pass 1) then EOT to BOT on channels 5 to 8 (Pass 2).

In 1994 noise was observed at the end of playback (beginning of recorded data) from NBTR-A. Subsequent record/playback sessions revealed data dropouts on the tape. The bad data sections were compensated for by increasing NBTR-B record overlap with NBTR-A. The UARS Flight Operations Team (FOT) executed a number of tests to better understand the conditions responsible for the anomaly. A significant level of NBTR-A playback data degradation was present. It was determined that NBTR-A was unreliable, and NBTR-B should be used solely for science data capture. On 26 October 1999 problems similar to those on NBTR-A began to intermittently appear on NBTR-B. Starting 30 October 1999 NBTR-B operations were suspended and additional TDRSS events were added or lengthened to compensate for the lost science data.

A test plan was developed and executed for NBTR-B. The FOT conducted a number of tape spooling tests, where the tape was spooled back and forth from BOT to EOT. These tests involved a fast wind of the recorder from BOT to EOT three consecutive times. Five record/dump sessions were scheduled with complete success. Record/Dump sessions were then stretched to use most of the tape with 100 percent data capture resumed. During this test period the problem was not present. On 5 November 1999 the Anomaly reoccurred: one good dump was reported; the rest were bad.

The FOT initiated NBTR-B 4-Mux mode testing on 6 November. The first test recorded data using channels 1-4 from BOT to EOT (Pass 1 only). This test was unsuccessful. Playbacks were again suspended. This test was repeated on 8 November with no success. The 4-Mux mode was tested again on 9 November. This time the test included Pass 2. The test was partially successful; Pass 2 data was captured while Pass 1 data were lost. The test was repeated

*(continued on page 22)*

*(continued from page 21)*

with Pass 1 data successfully captured on the next record/dump session. All subsequent record/dump sessions were valid for Passes 1 and 2.

On 10 November the polarization of the transponder was switched from Right Hand to Left Hand Circular Polarization. This configuration change was done primarily to allow UARS to take TDRSS Multiple Access (MA) supports that are more readily available. NBTR-B operated nominally in the 4 MUX mode until November 22 when the Pass 1 side became noisy. Pass 2 data remained valid.

The FOT is currently maximizing coverage with TDRSS S-band Single Access and MA supports, and operating NBTR-B in the 4 Mux Mode to capture high priority science data when no TDRSS coverage is available. We, along with L3 Communication (the NBTR manufacturer), are continuing to study the tape anomaly to best determine the nature of the failure.

The current UARS ground system and flight software are limited to two TDRSS satellite operations at one time. This prevents full orbital coverage. The Compton Gamma Ray Observatory spacecraft, which also experienced Tape Recorder failures, operates at about 85 percent data capture in real-time mode with a three-TDRSS operations scenario. Consolidated Space Operations Contract Sustaining Engineering staff are reviewing the possibility of modifying the UARS flight software and ground system to accept three TDRSS inputs to maximize orbital coverage.

*By Rick Hudson*

*For more information, please contact Herman Williams/ UARS Mission Director/GSFC Code 581.3, via telephone at phone (301) 614-5044.*

## WIRE Testbed Project Update

The Wide-Field Infrared Explorer (WIRE) Testbed Project is actively accepting and working proposals to utilize the on-orbit satellite to perform various engineering and scientific evaluations. The objective of the project is to provide an affordable and accessible on-orbit spacecraft to the space community to enable science observations, accelerate technology readiness and infusion, verify operations concepts, and perform educational outreach.

WIRE is a three-axis stabilized spacecraft in a sun synchronous low earth orbit. The satellite uses its Charged Coupled Device (CCD) star tracker and full complement of gyroscopes to obtain a pointing accuracy better than 10 arcseconds, while limiting jitter to 1 arcsecond when making inertial observations. The project is willing to accept and manage risk in order to carry out investigations. Accordingly, the flight software may be modified, within acceptable risk to health and safety concerns, to enable the on-orbit evaluation of innovative algorithms.

This resource derives its funding solely from the individual experimenters. Experimenters must fund not only their own needs, but also provide the funds to operate the spacecraft, on a pro-rated basis, for the duration of their investigation. The availability of this resource depends upon the customer community.

For additional information, please visit the Testbed website at *http://wiretestbed.nascom.nasa.gov/* or contact one of the following:

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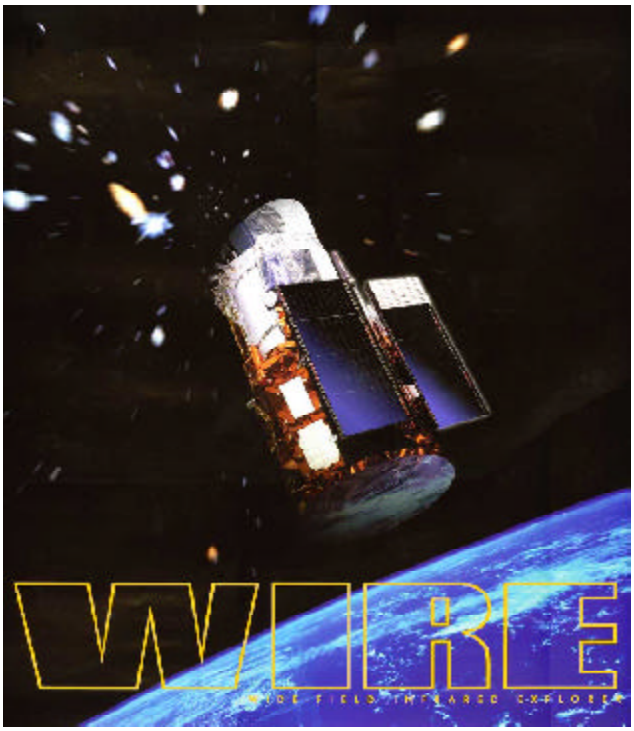
WIRE Mission Director
Systems Integration & Engineering Branch
patrick.crouse@gsfc.nasa.gov
(301) 286-9613

Robert Buchanan
Explorers Program Testbed Manager
Mission Integration & Planning Division
robert.buchanan@gsfc.nasa.gov
(301) 286-0491

*By Patrick Crouse/GSFC Code 581*



# WIND Achieves Landmark Orbital Backflip

The Global Geospace Science (GGS) Program, administered by the Goddard Space Flight Center, is the U.S. contribution to the International Solar Terrestrial Physics Program (ISTP). The principal objective of the GGS initiative is to gain understanding of the near-Earth space environment, and the flow of energy and plasmas within this environment. We are presently in a period of increasing solar activity leading to the Solar Maximum that occurs in the years 2000-2001. The GGS spacecraft are an important means to study the effects of this massive outpouring of solar energy on the Earth's environment.

Two spacecraft, WIND and POLAR, comprise the GGS program. WIND, launched in November 1994 follows a double-lunar swingby (DLS) trajectory that incorporates outer loops of from one to seven months' duration, interspersed with lunar swingbys and phasing orbits. These outer loops have had apogees of from 130 to 240 Earth radii (Re) in the direction of the sunward libration point L1. The POLAR spacecraft, launched in February 1996 is in an elliptical orbit around the Earth, and, in addition to its complement of plasma instruments, incorporates ultraviolet, visible and x-ray imagers for investigating the northern auroral belts.

Following completion of its nominal mission, the WIND spacecraft entered a period of high inclination orbits of from 45 to 50 degrees ecliptic inclination. These orbits, when viewed on the X-Y plane in GSE coordinates (Figure 1), describe a radial pattern similar to the petals of a flower, hence the term "petal orbits." For scientific reasons, a full 360-degree series of petals is not executed. Rather, the series is terminated at the halfway

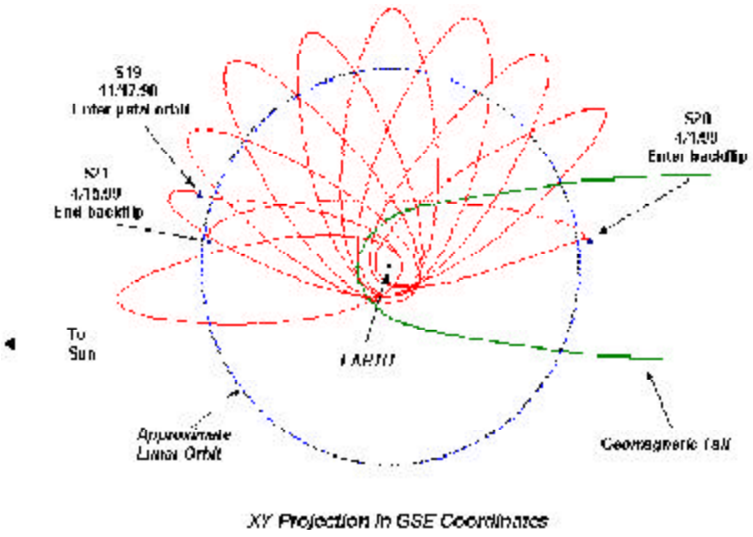



Figure 1. WIND's First Petal Orbit and Backflip

point by a maneuver, termed a "backflip," to return the spacecraft to a dayside, double lunar swingby trajectory.

To quote Heather Franz, the WIND Flight Dynamics specialist: "The WIND backflip maneuver, was the first ever executed by a spacecraft. The backflip was initially proposed as a means to transition a spacecraft like WIND from a sunward DLS orbit to a similar orbit in the anti-sunward direction. WIND's backflip accomplishes the opposite transition, from a nightside to a dayside orbit. The backflip effects a 180-degree rotation of the orbital line of apsides, thus changing the orbit from a nightside to a dayside orientation. Achieving the same orbital changes solely with propulsive maneuvers would require several hundred meters per second of delta-V, more than the entire mission's fuel budget at launch."

To date, two such backflips have been executed, the first in April 1999, the more recent in January-February 2000 (Figure 2). During the backflip in April

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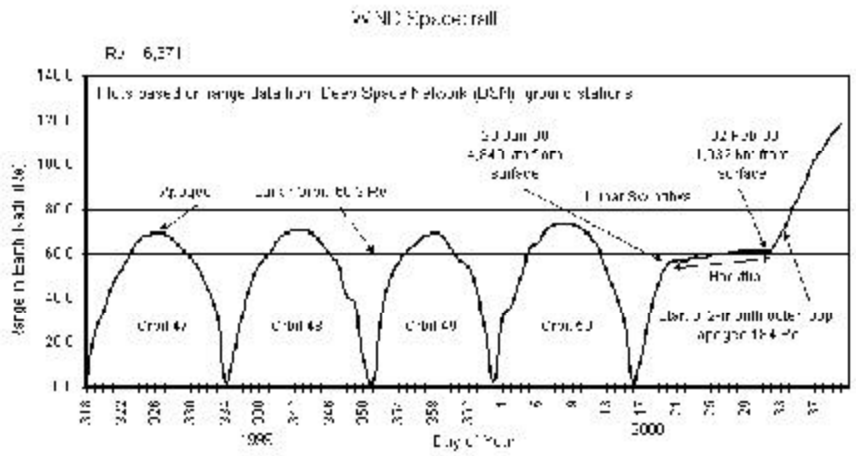



Figure 2. Petal Orbits, Lunar Swingbys, and the Backflip

*(continued from page 23)*

1999, the initial lunar swingby–about 600 km from the surface–sent the spacecraft above the ecliptic plane and adjusted the spacecraft's orbital period to approximate that of the Moon. As a result, the spacecraft again encountered the Moon about 13.6 days later on the opposite side of the Moon's orbit around the Earth, at a distance of 19,189 km from the lunar surface. Such a trajectory is extremely sensitive to the slightest perturbations. To ensure that errors in knowledge of the trajectory did not lead to spacecraft impact on the moon, periods of intensive tracking using Deep Space Network (DSN) ground stations were required to provide sufficient data for definitive trajectory solution. In addition, several small maneuvers were executed at strategic locations during the backflip to ensure its successful completion.

Thus, WIND has successfully proved, in two instances, that the theoretical backflip concept can be translated into a practical trajectory design that can be executed at a very reasonable fuel cost.

For more information on this groundbreaking maneuver, including diagrams depicting the backflip from a different perspective, see the Multimission Flight Dynamics Facility article on page 9.

*By John Wainwright/LMECO*

*For additional information on this topic, please contact Steve Pukansky/ LMSI via telephone at (301) 286-9313, or via email at Spukansk@pop500.gsfc.nasa.gov.*

# Additional Activities

## SPTR Provides Link for Millennium Broadcast

On New Year's Eve 1999, the South Pole TDRSS Relay (SPTR) Ku-Band Return link was used to transmit live video for broadcast around the world. The SPTR Ku-Band Return link is usually used to transfer large science data files out from the South Pole at 2 Mbps. For the New Year's Eve broadcast, an MPEG-2 digital video encoder was connected to the SPTR system, to provide a video and audio feed at 5 Mbps. The digital video and audio were decoded at the White Sands Complex, where the analog TV signal was fed into the GE-2 satellite link which is used during Shuttle flights. This feed was picked up by the ABC and PBS television networks in the United States, as well as other international stations such as the BBC. Video from the Pole included the annual marking of the location of the actual South Pole, and descriptions of some of the polar science activities. This was the first live, worldwide TV broadcast from the South Pole ever.

The South Pole Millennium Broadcast was supported under a grant to WGBH Boston from the National Science Foundation (NSF).

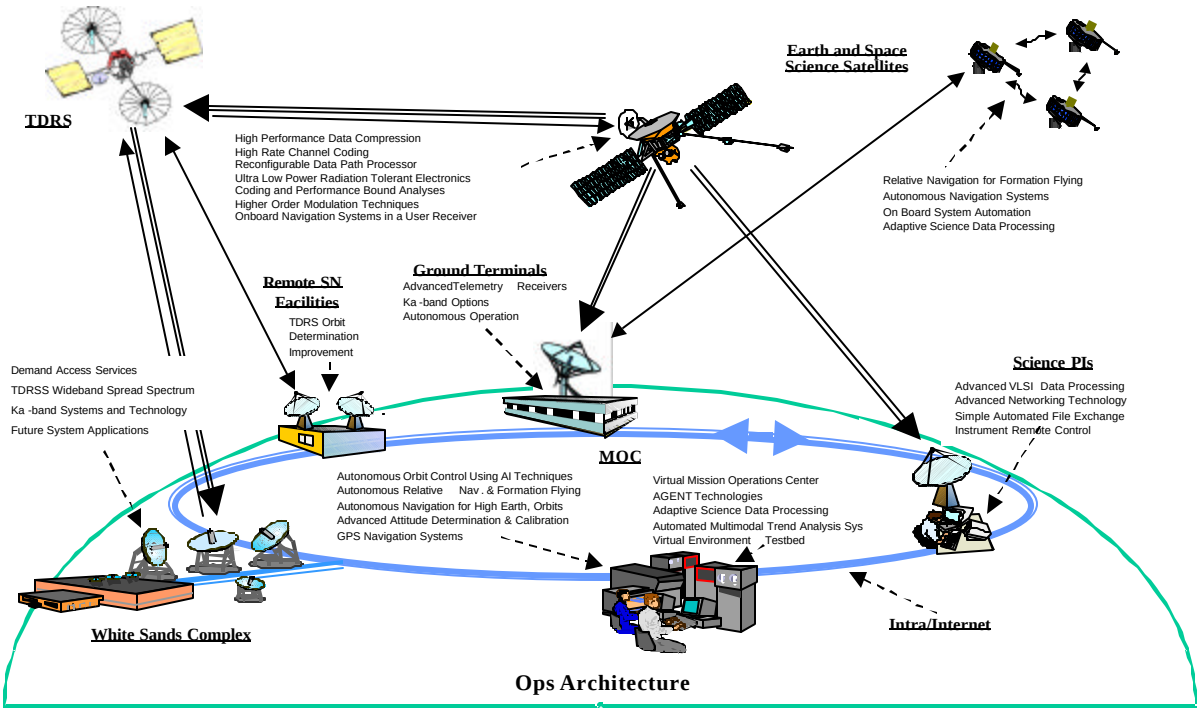
*By Dave Israel/GSFC Code 567.3*

*For more information, please contact the author at (301) 286-5294, or via email at dave.israel@gsfc.nasa.gov*

## Space Operations Technology Development at GSFC

The Space Operations Management Office (SOMO) located at Johnson Space Center has lead project responsibility for the Communications Technology Project. This project develops leading-edge space operations technologies that improve the efficiency and cost effectiveness of future mission operations supporting the objectives of the science community. The main goals of this project are to identify, develop, validate, integrate, and infuse technology that will increase performance, provide new capabilities, and reduce the costs of providing data and mission services to space operations customers. These technologies are broken into five major campaign areas in the Communications Technology Project Plan at JSC: Advanced Communications; Advanced Guidance, Navigation and Control (GN&C); Space Internet; Virtual Space Presence; and Autonomous Mission Operations.

GSFC is participating in this project by developing new and innovative hardware and software technologies. Code 450 has enlisted the expertise of the Applied Engineering and Technology Directorate (AETD), Code 500, to accomplish the goals of this project. Code 500 is providing technology development, program management, and engineering talent to ensure that the technology being developed is in line with NASA Enterprise (Space Science, Mission-to-Planet-




The Space Operations Network

Earth, Human Exploration and Development of Space, and Aeronautics and Space Transportation Technology) needs, and is capable of transition into the Space Operations Integrated Operations Architecture (IOA).

Other participating NASA Centers include Glenn Research Center (GRC) and Marshall Space Flight Center (MSFC). The California Institute of Technology, Jet Propulsion Laboratory (JPL) also participates in this technology development project. All of these entities work together in a cooperative environment to provide an integrated program for developing the future technologies needed to support the space operations mission of the future. The figure above shows the Space Operations Network, and the areas where GSFC has new technology development efforts in place.

GSFC has established seven work areas in response to the five campaign areas in the JSC Plan. These seven areas are briefly described below, and follow-on articles in later issues of *The Integrator* will describe each of the work areas in more detail from a mission and data services perspective. Each of these work areas supports a particular campaign area as shown below.

### *Advanced Modulation, Coding, Processing, and Compression*

The objective of this work area is to enable more spacecraft to emanate transmissions of increasingly larger information rates under the constraints of limited budgets, EIRP, channel bandwidth and/or buffer capacity, and to provide matching, low cost/high performance ground processing functionality.

*(continued on page 26)*

| Campaign Area | GSFC Work Area |
|---|---|
| Advanced Communications | ▪ Advanced Modulation, Coding, Processing, and Compression<br>▪ Advanced Space and Ground Networks<br>▪ Search and Rescue Technology Insertion |
| Advance GN&V | ▪ Flight Dynamics Technologies |
| Space Internet | ▪ Spacecraft as an Internet Node |
| Virtual Space Presence | ▪ Tools for Autonomous Systems |
| Autonomous Mission Operations | ▪ End-to-End Mission Autonomy |

*(continued from page 25)*

### *Advanced Space and Ground Networks*

This work area provides the surveys, studies, analyses, developments, testing programs, demonstrations, and implementation architecture required for the application of new technologies that support the growth and effectiveness of the NASA Space Network and Ground Network communications infrastructure.

### *Search and Rescue Technology Insertion*

Staff in this work area develop applications of aerospace technology that improve search and rescue timeliness and effectiveness consistent with NASA's responsibilities as a member of the National Search and Rescue Committee, and as a signatory of the National Search and Rescue Plan. Specific work area objectives are:

- Expansion of the satellite beacon customer community
- Development of effective search methods to use when a beacon fails to operate
- Improved real-time global alerting and locating capability

### *Flight Dynamics Technologies*

In this work area, autonomous maneuver decision making, planning, and execution techniques are being extended to enable distributed networks of individual vehicles to interact with one another, acting as a single functional unit. Activities are being focused in three areas:

- Automated navigation /advanced studies to develop techniques and tools which enable a distributed network of individual autonomous vehicles to act collaboratively, exhibiting a common system-wide capability
- Onboard navigation systems algorithm development, and studies to assess the feasibility, accuracy, and capability of autonomous navigation through Doppler from a one-way crosslinked communication signal between two or more spacecraft flying in formation
- Automated orbit control using artificial intelligence tools and techniques for spacecraft operation

### *Spacecraft as an Internet Node*

The objective of this work area is to demonstrate and infuse technologies that make it practical and cost effective to build and operate missions as nodes on the Internet. An intermediate objective of the Operating Missions as Nodes on the Internet (OMNI) task is to demonstrate these technologies and concepts in the form of a prototype mission operated in a distributed fashion through ordinary Web browsers on standard workstations located in offices or laboratories. The prototype mission is to built around standard commercial LAN and Commercial Internet Protocol communications and interfaces.

### *Tools for Autonomous Systems*

In this work area GSFC staff will develop technologies and tools to assist scientists and mission operations personnel with lights out operations, data visualization, and specifying high-level science objectives. Some of the goals of this work area include:

- A system to interact with humans as needed during beacon mode operations
- A visualization system that enables mission operators to more easily detect less obvious anomalies
- A system that enables mission operators to monitor a large amount of spacecraft data at one time
- A visualization system that enables lights-out control centers to perform rapid and remote analysis in a crisis situation
- Providing the scientists with data visualization and animation capabilities

### *End-to-End Mission Autonomy*

The overall objective of the GSFC "End-to-End Mission Autonomy" work area is to significantly advance the automation of the end-to-end mission systems to improve science data collection, reduce development and operations cost, and enable constellation missions through transparent, autonomous mission operations. These objectives are in direct response to the Enterprise needs for cost-effective mission autonomy, which is necessary for many future missions with challenging observational and/or exploration mission concepts.

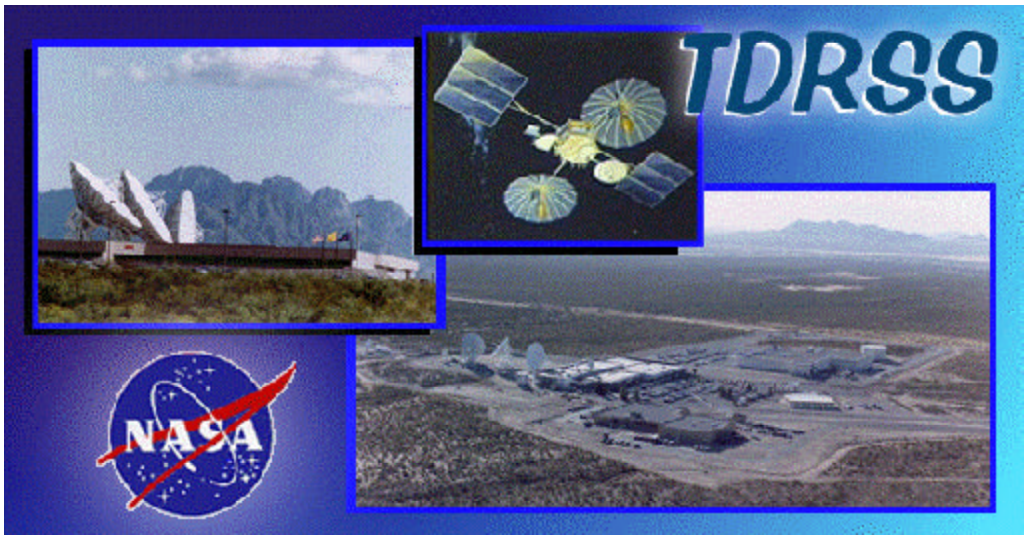
*By Robert Savage/GSFC Code 500*

*More detailed information and points of contact can be found at the following URL:*
*http://aetd.gsfc.nasa.gov/technology/index.html.*

## Log on to the TDRSS On-line Information Center

Have questions about TDRS or the Space Network (SN)? Check out the TDRSS Online Information Center. New information about SN services over TCP/IP is provided. We have expanded our information modules about PORTCOM, ECOMM and TILT. Our link budget calculators will help you determine if your mission can be supported by TDRSS. Our Javascript search engine will help you locate the specific information you are looking for. You can also email us your questions using our feedback form. We will direct your question to the appropriate expert, and return an answer directly to you via email. The site is updated twice monthly to ensure information is current and accurate.

The website can be found at *http://nmsp.gsfc.nasa.gov/tdrss/*




Detailed information is currently available on:

- The Tracking and Data Relay Satellites (including TDRS H, I, J)
- The White Sands Complex including WDISC
- Guam Remote Ground Terminal
- McMurdo TDRSS Relay System
- TDRSS Telecommunication Services
- Customer Communication Systems and Products (including Transponders)
- TDRSS Applications
- PORTCOM, ECOMM and TILT

Plus much more…

## Space Network Scores Triple Play: Terra/STS-103/HST Simultaneous Support

The Space Network (SN) closed out the 20th century with a spectacular, and precedent-setting, achievement by simultaneously supporting the EOS Terra (AM-1) launch and early orbit, the STS-103 launch and on-orbit activity, and the Hubble Space Telescope (HST) service mission requirements.

Initially, the Terra and STS-103 launch dates were widely separated. By mid-December, however, they were only 18 hours apart, with Terra scheduled to launch from the Vandenberg, CA launch complex and STS-103 from Kennedy Space Center. Shuttle launch slips normally create havoc with the SN schedule, but with both Terra and STS-103 leapfrogging their way through December, the Goddard Network Control Center (NCC) schedulers were extremely busy trying to keep up with nearly continuous rescheduling efforts.

There were some who had serious concerns that simultaneous support of these three highly critical and highly visible missions was extremely risky and inadvisable, because anything other than 100% success would be viewed as failure in light of the recent problems with the NASA Mars missions. But Terra was ready to go; their next launch opportunity not being until January—a "century away." HST had lost another gyro, and any further delay would increase the risks to the spacecraft and the difficulty associated with a successful grapple and repair. Both the White Sands Complex (WSC) and the Goddard Network Control Center said they were ready for support. There seemed to be no other choice than to go ahead with the missions.

Terra launched on December 18, closely followed by the Shuttle liftoff on December 19. The rest, as they say, is history. Terra, STS-103, and the HST servicing mission were all a complete success. The Shuttle and crew returned safely after repair of the Hubble spacecraft, HST is now back to providing invaluable space science, and Terra will soon begin to gather the first science data of its Mission to Planet Earth.

Congratulations to the Space Network personnel at the WSC and the NCC, and to those in the Shuttle, HST and Terra projects for closing NASA's books on the 20th century with resounding success.

*By Dick Schonbachler/ GSFC Code 451*

*For additional information on this topic, please contact the author via email at Richard.M.Schonbachler@gsfc.nasa.gov.*

## GSFC Survives Y2K Transition Intact!

We are pleased to report that GSFC executed a nearly seamless transition to the Year 2000. In fact, very few Y2K-related problems were reported from any of NASA's systems, and no problem was significant enough to affect the operations of NASA's missions, facilities, or projects.

During the critical December 31 to January 1 time period, the GSFC Y2K Project team monitored Goddard systems and tracked any occurring anomalies. At the stroke of midnight, GMT (7 p.m. EST on December 31,1999) Goddard missions experienced the transition to the new year. Within a few hours, GSFC received confirmation that all operating missions were continuing unaffected. There was only one Y2K-related anomaly experienced by a GSFC mission—a minor glitch that did not affect operations occurred in a UARS flight dynamics planning tool.

As midnight approached on the East coast, the GSFC Y2K Project team was anticipating a smooth transition to the new year. They were not disappointed. No significant problems were reported at either GSFC or Wallops Flight Facility. By 1:10 a.m. EST the team reported that all facilities were operating normally.

Congratulations to all of you who were involved in the planning, testing, and execution of this endeavor. We succeeded in turning a potentially mission-threatening crisis into a non-event.

## Yosemite ’99 Project Demonstrates a Virtual Crosslink

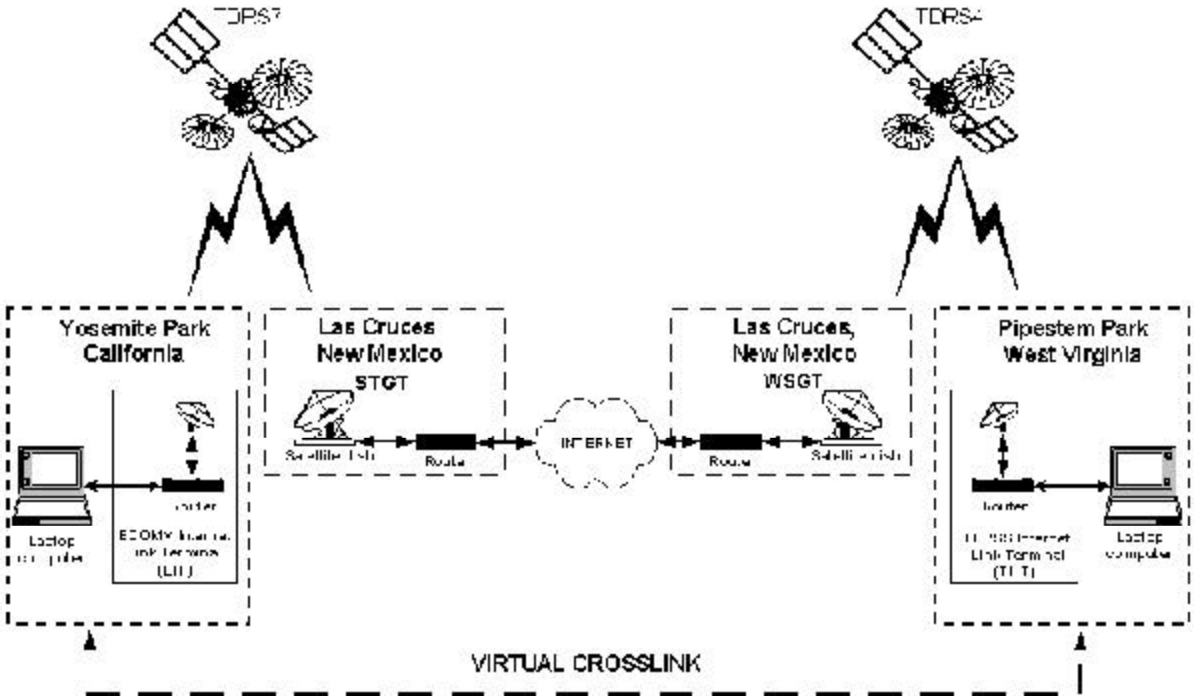
During the week of December 7th, the TDRSS network supported the Yosemite ’99 project. The Yosemite ’99 project was an Advanced Placement Biology project sponsored by the GSFC Education Office in conjunction with Blue Ice International, a non-profit organization dedicated to establishing interactive global learning networks. In Yosemite ’99, California high school students visited Yosemite Park, California, while students in West Virginia went to Pipestem Park in their home state. At each park the students made various measurements of soil and water composition, and were able to share data with the students at the other park via a “virtual crosslink” provided by TDRSS.

The virtual crosslink between the two parks was accomplished by providing each group with a connection to the Internet via a different TDRSS satellite. The TDRSS Internet Link Terminal (TILT) was in West Virginia using TDRS-4, and the Early Communications (ECOMM) Internet Terminal (EIT) was in Yosemite using TDRS-7. The TILT provided a 1024 kbps bidirectional Internet connection while the EIT provided a 128 kbps bidirectional Internet connection. The two groups could send messages from one park to the other as if they had a direct crosslink. This same technique could be used for two Internet Protocol (IP) spacecraft in orbit that do not have a view of each other, but are both using TDRSS or an IP ground station. One could send a message to the other just by addressing it to the IP address of the other spacecraft. When the signal got to the ground stations, the routers would direct the message to the other spacecraft. No processing by humans or other computers would be necessary.

The Blue Ice International project is currently planning a trip to Antarctica in 2001. They intend to use TDRSS to support that mission as well.

For more information see:
*http://www.blueiceonline.com*
*http://education.gsfc.nasa.gov/yosemite99/*
*http://rodent.gsfc.nasa.gov/tilt*

*By Dave Israel/GSFC Code 567.3*




Block Diagram of Virtual Crosslink Demonstration Using TDRSS and Standard IP Services

# Code 450 Now Has a Logo!

# New Mission Services Projects Schedule Unveiled

We are pleased to provide a new milestone chart, the **Mission Services Projects Schedule**, in this issue of *The Integrator*. This chart shows vital activities slated to occur in the next five to seven years for all Code 450 elements. Depicted events include test schedules, reviews, launches, software releases, and other important milestones. We will update this chart as needed, providing up-to-date versions in future issues of this publication.

***Edited by***: Lena Braatz (Booz·Allen & Hamilton)
***Layout & Illustration by***: Sherri Tearman (Booz·Allen & Hamilton)

***The Integrator*** can be found on line at *http://nmsp.gsfc.nasa.gov/integrator/*

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